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Current results of an arachnological survey of some sandstone rock sites in Bohemia (so-called "rock cities")

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Abstract. Current results of an arachnological survey of some sandstone rock sites in Bohemia (so called "rock cities"). The spider fauna of the Adrspach-Teplice rocks was investigated. Some records on spider fauna of other nine sandstone rock areas are included. The phenomenon of "rock cities" manifests itself in three aspects: (1) In the bottom parts are microclimatically cold spaces, frequently hosting northern or mountain species of invertebrates, which here have an azonal occurrence. (2) The sun exposed tops of rocks can host thermophilous species. (3) Some species are limited to the surface of rocks and boulders. These are referred to as lithophilous or lithobiont species.

Key words: Araneae, sandstone, rocks, lithobiont.

INTRODUCTION

Massive layers of Upper Cretaceous block sandstones jut out at many sites in the northern and northeastern Bohemian Cretaceous Basin. The presence of fissures, and the different resistance of the individual sandstone layers, induce weathering of the initially compact sandstone plates and thereby the development of diverse shapes. Narrow rocky gorges originated from the destruction of fissure zones, which proceeded particularly by mechanical weathering, mostly by cryogenic erosion, as a result of freezing of water trickling down the fissures. Further shaping of the ground was contributed to by gravitational motions, by the breakdown of rocks, by erosion through water streams, by the effect of snow accumulating in the gorges, etc. Typical macroforms of the relief of sandstone regions are narrow gorges and broad canyons. Additional weathering gives rise to isolated rocks or to rock systems with labyrinths of narrow corridors which, in their perfect form, can constitute the well-known "rock cities". Typical mesoforms of sandstone relief are pseudokarst caves. A great abundance of niches, ledges and honeycombs are found on the surface of rocks and boulders.

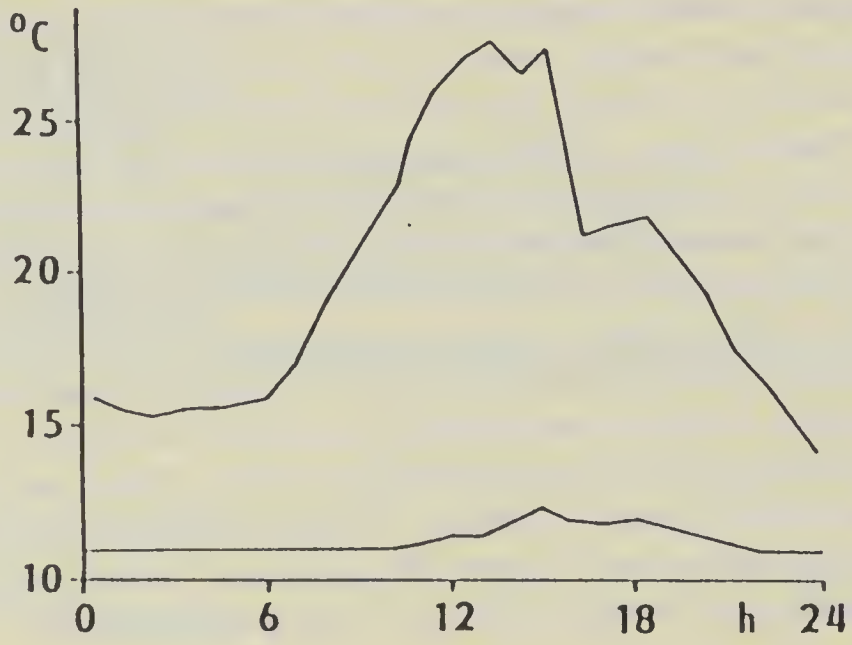
"Rock cities" have their own specific microclimate. The upper parts of rocks and open rock walls oriented to the south are parched, and in sunny days "overheated". Narrow, deep gorges and caves, on the other hand, keep cold air all the year round. Local air currents, water streams and, in particular, slipped-down snow, which can persist in the galleries till summer, also play a role for the microclimate. The extreme cold is the cause of the inversion of vegetation zones in gorges. The degree of inversion may allow the formation of subalpine plant communities.

BALATKA & SLADEK (1984) gave an overview of the geomorphology of the whole block sandstones area in the Bohemian Cretaceous Basin. They report on twenty-two geomorphological subdistricts, which are characterised by the presence of "rock cities".

STUDY AREA AND METHODS

The Adrspach-Teplice rocks attain altitudes of 470 to 780 m, they lie in the CH 7 cold climatic region (QUITT 1975), squares of grid-mapping of organisms 5362 and 5462 (BUCHAR 1982). The area of the whole rock complex is about 28 km².

Fig. 1 Daily course of temperature in the settlement Adrspach (upper curve) and in the Karlova Ulicka gorge in the "rock city" (lower curve) (from DOHNAL 1950).



Two typical, well-developed "rock cities" occur in this region. The Adrspach rocks are rich in solitary formations. The height of the rocks reaches 60 m.

The Teplice rocks are bulky and include classical canyon valleys, whereas solitary formations are sparse; the rock height attains 70 m. Between the two compact "rock cities" are extensive areas of gorges and rock labyrinths. Various types of caves have also developed. The entire region is crossed from the west to the east by the Vlci Rokle gorge (VITEK 1979). In the coldest spaces of the "rock cities", snow persists to July and the temperature is constantly below 10°C (Fig. 1). Alpine and mountain plant species (*Viola biflora, Mulgedium alpinum, Homogyne alpina)* and arcto-alpine moss species (*Andreaea petrophila*) occur in the gorges, and the rare high-mountain bryophyte *Scapania uliginosa* grows in streams (DOHNAL 1950, SYKORA & HADAC 1984).

The spider fauna of the Adrspach-Teplice rocks was studied intensively in autumn. The first material from the Adrspach-Teplice rocks was collected by A. and V. RUZICKA in July 1986. In 1986-1989 J. KOPECKY collected spiders at root stalagmite localities in pseudokarst areas of the Broumovska Vrchovina highland. The results stimulated field trips in October 1987 and in November 1990. Material was collected by sieving, sweeping, beating, and hand-collecting on rocks, under stones, etc., as well as by treating samples of moss and upper soil layers in a Tullgren funnel.

With respect to their position and to the grid-mapping of organisms, the sites visited were divided as follows:

1. The Adrspach "rock city" region (square 5362). Collection was accomplished on rocks of the "rock city" and of the Rerichova Rokle and Vlci Rokle gorges, at the peat bog below the Adrspasske Jezirko lakelet, at the peat bog near the upper branch of the blue tourist path, among stones near the brook, on the southwardly exposed slopes of the Vlci Rokle gorge covered by heather and by overheating tussocks of dry fern.

2. The Teplice "rock city" region (square 5462). The material was collected at the U Ozveny site, on the top rocks of the Strmen castle, near the mouth and vent-hole of the Teplicka Jeskyne cave, in this debris cave, on rocks near the Korenka cave in the upper section of the rocks, inside the "rock city" and the underground spaces of the Bludiste (Labyrinth) region.

Besides some records of non-systematic spider-collections of nine other rock areas are included. The areas are listed in Tab. 3, a location map is given in Fig. 2.

RESULTS

A total of 1'019 spiders, belonging to 82 species, was collected in the Adrspach-Teplice rocks (Tab. 1). The majority was collected in the coldest spaces of the Teplice "rock city" and in leaves and thick moss on block debris near the mouth and vent-hole of the Teplicka Jeskyne cave. Seventeen species (21 %) were relicts of the 1st rank, i.e., their centre of occurrence is at sites very similar to the original natural conditions (BUCHAR 1983, 1989): *Araeoncus crassiceps, Bathyphantes simillimus, Centromerus arcanus, C. pabulator, Dicymbium tibiale, Diplocentria bidentata, Diplocephalus helleri, Drepanotylus uncatus, Hilaira excisa, Lepthyphantes arciger, L. monticola, L. mughi, L. obscurus, L. pallidus alutacius, Poeciloneta globosa, Porrhomma convexum,* and *Typhochrestus digitatus*. These species constituted as much as 38 % of specimens collected. Abundant occurrence of the *Drepanotylus uncatus* species was only observed in *Sphagnum* in the Vici Rokie gorge. The species *Centromerus arcanus, Dicymbium tibiale, Hilaira excisa,* and *Lepthyphantes monticola* were found partly in *Sphagnum* in the Vici Rokie gorge and partly in the Teplice rocks, whereas the remaining 1st rank relicts occurred only in the Teplice rocks. Fourteen out of the seventeen 1st rank relicts were psychrophilous species (sensu BUCHAR 1975, 1989), occurring mainly in the oreophyticum, in the regions of the mountain flora of Czechoslovakia

Tab. 1 Review of the material from the Adrspach rock city region and Teplice rock city region. Thermopreference (BUCHAR 1975, 1989) and relict status (BUCHAR 1983, 1989): P - psychrophilous, N - non specific, M - mesotherm, T - thermophil, I - 1st rank relict, II - 2nd rank relict, E - expansive species. ♂ / ♀ / J.

		Adrspach rocks	Teplice rocks
P II	Segestria senoculata (L., 1758)	-	1/-
P E	Nesticus cellulanus (CL., 1757)	-/1	1/1
P II	Bathyphantes approximatus (O. P.-CBR., 1871)	-/1	-
N II	B. gracilis (BL., 1841)	2/3	1/1
P II	B. nigrinus (WESTR., 1851)	1/2	-/2
N E	B. parvulus (WESTR., 1851)	-	1/-
P I	B. similimus (L. KOCH, 1879)	17/21	49/83
P II	Bolyphantes alticeps (SUND., 1832)	-/1	1/2
P I	Centromerus arcanus (O. P.-CBR., 1873)	7/11	11/4
P I	C. pabulator (O. P.-CBR., 1875)	-	1/2

		Adrspach rocks	Teplice rocks
N E	C. sylvaticus (BL., 1841)	1/-	-/1
P E	Diplostyla concolor (WIDER, 1837)	-/1	-
P II	Drapetisca socialis (SUND., 1835)	2/3	1/4
P I	Drepanotylus uncatus ((O. P.-CBR., 1873)	16/28	-
P II	Helophora insignis (BL., 1841)	-	-/1
P I	Hilaira excisa (O. P.-CBR., 1871)	-/1	-/1
P II	Labulla thoracica (WID., 1834)	-	-/1/5
P II	Lepthyphantes alacris (BL., 1853)	30/22	99/79
P I	L. arciger (KULCZ., 1881)	-/1	2/-
P II	L. cristatus (MENGE, 1866)	3/5	-
N II	L. mansuetus (THOR., 1875)	-/1	-
P I	L. monticola (KULCZ., 1881)	1/-	7/19
P I	L. mughi (FICK., 1875)	-	13/16
P I	L. obscurus (BL., 1841)	-	1/-
? I	L. pallidus alutacius SIM., 1884	-	-/2
P II	L. pulcher (KULCZ., 1881)	-/10	2/6
P II	L. tenebricola (WID., 1834)	-/2	-/6
P II	Linyphia clathrata SUND., 1829	2/2/1	-
? E	L. montana (CL., 1758)	-/1	-
N E	L. triangularis (CL., 1758)	1/8	1/4
N II	Macrargus rufus (WID., 1844)	-/1	2/3
N E	Meloneta rurestris (C. L. K., 1836)	2/3	1/1
N E	Microlinyphia pusilla (SUND., 1829)	-/1/1	-
N II	Microneta viaria (BL., 1841)	1/1	3/7
P I	Poeciloneta globosa (WID., 1834)	-/1	-
P II	Pityohyphantes phrygianus (C. L. K., 1836)	1/-/1	-/1/1
P II	Porrhomma convexum (WESTR., 1861)	-	1/1
P II	P. pallidum JACKS., 1913	-	16/45
	P. sp.	-	-/1
P I	Araeoncus crassiceps (WESTR., 1861)	-	-/1
N E	A. humilis (BL., 1841)	-	1/1
P II	Asthenargus helveticus SCHENKEL, 1936	-/1	1/-
P II	Cnephalocotes obscurus (BL., 1834)	1/1	-
N I	Dicymbium tibiale (BL., 1836)	6/1	1/-
P I	Diplocentria bidentata (EMERTON, 1882)	-	17/21
P E	Diplocephalus cristatus (BL., 1833)	-/1	-
P I	D. helleri (L. K., 1869)	-	6/7

		Adrspach rocks	Teplice rocks
N II	D. latifrons (O. P.-CBR., 1863)	1/4	10/10
P II	Dismodicus bifrons (BL., 1841)	-/1	-
P E	Erigone dentipalpis (WID., 1834)	-	1/2
P II	Erigonella hiemalis (BL., 1841)	-	-/1
P II	Gonatium rubellum (BL., 1841)	-/7	-
P II	Gongylidiellum latebricola (O. P.-CBR., 1871)	1/2	-
P E	Micrargus herbigradus (BL., 1854)	1/1	11/17
P II	Oedothorax agrestis (BL., 1853)	5/10	-
N E	O. apicatus (BL., 1850)	-/1	-
P II	Pelecopsis elongata (WID., 1834)	3/4	-
N E	Pocadicnemis pumila (BL., 1841)	-/6	-
P E	Thyreosthenius parasiticus (WESTR., 1851)	9/15	-/7
T I	Typhochrestus digitatus ((O. P.-CBR., 1872)	-/2	-
N II	Walckenaeria antica (WID., 1834)	-	-/1
N II	W. mitrata (MENGE, 1868)	1/-	-
P E	Meta menardi (LATR., 1804)	-/1	-
P II	M. mengei (BL., 1869)	3/1	-
PE	M. merianae (SCOP., 1763)	-/3	6/4
P II	M. segmentata (CL., 1757)	-/2	-
N II	Tetragnatha pinicola L. K., 1870	-/1	-
P E	Pardosa amentata (CL., 1758)	-/-/3	-
N II	P. lugubris (WALCK., 1802)	-/-/1	-
N II	Coelotes terrestris (WID., 1834)	-/1	-/2
N II	Tegenaria silvestris (L. K., 1872)	-/1	-
P II	Cryphoeca silvicola (C. L. K., 1834)	3/2	1/1/1
N E	Dictyna uncinata THOR., 1856	-/1	-
P II	Amauroblus fenestralis (STRÖM., 1768)	4/4	-/3/3
P II	Calloblus claustrarius (HAHN, 1831)	-/3/4	-/-/2
P II	Clubiona reclusa (O. P.-CBR., 1863)	-/1	-
P II	C. subsultans THOR., 1875	1/1	-
N II	Zora spinimana (SUND., 1833)	1/2/1	1/-
N II	Z. nemoralis (BL., 1861)	-/-/1	-
N E	Xysticus audax (SCHR., 1803)	-	-/1
N E	X. cristatus (CL., 1757)	-/3	-/2
N II	Neon reticulatus (BL., 1853)	-/2	-

(SLAVIK 1984; HEJNY & SLAVIK 1988). Only *Typhochrestus digitatus* is a thermophilous species, *Dicymbium tibiale* is nonspecific, and the character of the subspecies *Lepthyphantes pallidus alutacius* is not clear. The species *Araeoncus crassiceps, Centromerus arcanus, C. pabulator, Dicymbium tibiale, Diplocephalus helleri, Lepthyphantes arciger, L. mughi, L. obscurus* and *Porrhomma convexum* occur nearly exclusively or predominantly in mountain altitudes.

The material was collected both on rock and on vegetation. As to rock walls, the collecting was performed predominantly in shaded, inverse locations. A part of the material was from more open, exposed locations. Confining ourselves to rocks and to surfaces of boulders, we can pick out a group of species characteristic for this environment. Based on the differences between the sites and abundances of the species, we can set up an approximate sequence of species with respect to their occupation of

Tab. 2 Percentage of specimens of characteristic species in collection from rock surface on various localities of Adrspach-Teplice rocks and Broumovske Steny walls. *Lepthyphantes pulcher, L. alacris, Thyreosthenius parasiticus, Drapetisca socialis, Bathyphantes simillimus, Nesticus cellulanus, Micrargus herbigradus, Diplocephalus helleri.* Total number of specimens.

	%								Total
	L.pul.	L.ala.	T.par.	D.soc.	B.sim.	N.cel.	M.her.	D.hel.	number
Strmen - wind-swept bare top parts of rocks	60	40	-	-	-	-	-	-	5
Korenka -shaded rocks in forest on structural plateau	-	38	25	6	31	-	-	-	16
Adrspasske skaly - open parts on the "rock city"	3	3	14	-	77	3	-	-	30
Berichova rokle - shaded rocks in forest gorge	-	-	21	-	79	-	-	-	19
Kovarova rokle - deep rock gorge	-	13	-	-	87	-	-	-	8
Bludiste, Teplicka jeskyne - underground spaces in debris cave	-	-	-	-	86	7	7	-	14
Teplicke skaly - the coldest narrow parts of the "rock city"	-	2	-	1	90	1	1	6	97

the rock walls in the height profile, from upper parts exposed to weather down to the bottom shaded cold parts (Tab. 2). Two opposite extremes which overlap slightly are the lithobiont species *Lepthyphantes pulcher* and *Bathyphantes simillimus*. The former occupies predominantly exposed parts of rocks, whereas the latter occupies shaded and wet parts of rocks in narrow gorges, fissure-type caves and underground spaces of debris caves. Furthermore, from the top downwards the rock walls are occupied by the species *Lepthyphantes alacris, Thyreosthenius parasiticus, Drapetisca socialis, Nesticus cellulanus, Micrargus herbigradus* and *Diplocephalus helleri*.

DISCUSSION

The abundance of the psychrophilous mountain species in the Teplice "rock city" is a consequence of the exceedingly cold microclimate of their ground and underground parts. The unusual character of this site is also demonstrated by the fact that, although lying in the same climatic region as the Broumovske Steny and the Tiske Steny walls, only the Adrspach-Teplice rocks are included in the oreophyticum, the phytogeographic region of the mountain flora of Czechoslovakia (HEJNY & SLAVIK 1988).

The spider material of nine further rock sites, though not systematically collected, allows a few comments on the occurence of some abundant or exclusive species (Tab. 3).

The most characteristic species of the coldest parts of the Adrspach-Teplice rocks, Ostas table mountain and Broumovske Steny walls, is *Bathyphantes simillimus*. One female of this species was trapped in the coldest part of the Besedicke Skaly rocks, on the ceiling of a rock tunnel. WOZNY & CZAJKA (1985) presented this species under the name *B. eumenis*. Their concept was adopted by RUZICKA (1988). ESKOV (1988) recommended the name *B. simillimus* for Central European populations. According to this author, *B. eumenis* is distinguished from other closely related species by the presence of ventral spines on tibiae I and II, and its distribution area does not exceed the western Yenisey biogeographical border (ESKOV in litt.). In Europe, *B. simillimus* is a glacial relict. Its occurrence is known from sandstone "rock cities" and from stony debris. *B. simillimus* is the dominant species in spider communities of block fields on the ridge of the Giant mountains (RUZICKA et al. ms.). Recently,

this species has been found in stony debris in the Black Forest and the Vosges Mountains (BLICK 1991).

Lepthyphantes pulcher is a middle-European species living predominantly on rocks. ANTUS (1982) was able to trap this species on crystalline rocks only during night. During day the spiders were hidden in inaccessible fissures. Sandstone, however, forms no narrow fissures where the spiders might find shelter, and thus collecting this species on sandstone rocks was not a problem.

Tab. 3 The presence of selected spider species in the collections from sandstone "rock cities".

1 Adrspach-Teplice rocks (in total 82 species)
2 Ostas table mountain (5 species)
3 Broumovske steny walls (3 spp.)
4 Prachovske Skaly rocks (22 spp.)
5 Hruba Skala "rock city" (4 spp.)
6 Besedicke Skaly rocks and Maloskalsko region (32 spp.)
7 Suche Skaly rocks (1 sp.)
8 Kokorinsko region (5 spp.)
9 Tiske Steny walls (11 spp.)
10 Labske Piskovce sandstones (10 spp.)

	1	2	3	4	5	6	7	8	9	10
Bathyphantes similimus	+	+	+			+				
Lepthyphantes pulcher	+	+		+					+	+
Lepthyphantes alacris	+	+	+	+					+	
Drapetisca socialis	+	+		+					+	+
Thyreosthenius parasiticus	+	+		+		+			+	
Pelecopsis elongata	+					+				+
Nesticus cellulanus	+					+				+
Meta merianae	+				+	+				+
Meta menardi	+									+
Lepthyphantes nitidus	+						+			
Diplocentria bidentata	+									
Centromerus prudens								+		
Typhochrestus digitatus	+									
Theridion betteni						+				

Lepthyphantes alacris is abundant on rocks surface and also on vegetation.

Noteworthy is the occurrence of the species *Drapetisca socialis* on the bare surface of rocks. This species was supposed to live only on tree bark (particularly beech) (LOCKET & MILLIDGE 1953; WIEHLE 1956; MILLER 1971; WUNDERLICH 1982). It is likely that the occurrence of this species on rocks indicates the deciduous forests grown in this region, as the occurrence of some plant species indicates the original presence of beech forests in the Adrspach-Teplice rocks (DOHNAL 1952).

Thyreosthenius parasiticus lives in diverse biotopes which, however, have one thing in common, i.e. a wet and steady microclimate. Such an environment is provided by litter, decaying wood, bark spaces and tree hollows (KURKA 1981; RUZICKA et al. 1991) by compost and decaying hay (WIEHLE 1960), by animal burrows and bird nests (MILLER 1971), by farm buildings, cellars, sewers, mines (LOCKET & MILLIDGE 1953) and, last but not least, by "rock cities".

Pelecopsis elongata is a forest detritus species. It is found in "rock cities" and in stony debris too.

Nesticus cellulanus and species of the genus *Meta* occupy shady rock niches and cave entrances.

Lepthyphantes nitidus (syn. *L. kochi* KULCZ.) has been found in two "rock cities", and beyond them, e.g., on claystone rocks near Bezdekov nad Metuji. Its occurrence has been reported from various sites (BUCHAR 1989; MAURER & HÄNGGI 1990). However, in Poland it was always found under stones (CZAJKA 1963), which indicates an affinity for stony biotopes.

The find of *Diplocentria bidentata* in Teplicke Skaly rocks is the second record of this species in Czechoslovakia. It was first recorded by BUCHAR (1989) in stony debris on Plesivec Mountain in Ceske Stredohori Mts.

The species *Centromerus prudens* (O. P.-CBR., 1873) was for the first time found in Czechoslovakia after sieving moss from the "rock city" in the Kokorinsko region (BUCHAR 1989).

Typhochrestus digitatus is a photophilous and thermophilous species living on sandbanks and in lichen (TRETZEL 1952). In the open part of the Vlci Rokle gorge in the Adrspach-Teplice rocks it was found in low moss growing on sunny rocks.

Theridion betteni is a photophilous and thermophilous species living on bare rocks surface. It was found on sunny rocks in the Maloskalsko region.

CONCLUSIONS

The phenomenon of "rock cities" can manifest itself in three aspects.

1. The bottom parts of "rock cities" contain microclimatically cold spaces, frequently hosting northern or mountain species of invertebrate animals, which have an azonal occurrence (e.g. *Bathyphantes simillimus*, *Centromerus pabulator*, *Dicymbium tibiale*, *Diplocephalus helleri*, *Lepthyphantes pulcher*).

2. The sunexposed and parched tops of rocks with sparse, relict pines, on the other hand, can host some thermophilous species such as *Theridion betteni* and *Typhochrestus digitatus*.

3. Associated with the specific microclimate of the "rock cities", some invertebrate species live on the soil surface, in moss, on vegetation (e.g. *Centromerus pabulator*, *Lepthyphantes mughi*); other species, however, are limited to the stony substrate, to the surface of rocks and boulders. These are referred to as lithophilous or lithobiont species (e.g. *Nesticus cellulanus*, *Theridion betteni*, *Bathyphantes simillimus*, *Lepthyphantes pulcher*).

The fauna of invertebrate animals in "rock cities" certainly deserves more study, so that - along with the flora and the geomorphological character - it should become an equally important subject for conservation in protected territories.

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Fig. 2 The territory of block sandstones in north-east Bohemia - dotted (after BALATKA & SLADEK 1984). Sitenumbers are defined in Tab. 3.